A33C-0227: Surface CO_2 flux estimation with Greenhouse Gases Observing Satellite (GOSAT) ACOS v2.9 observations: OSSE and real observation experiments

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1. Introduction

The JAXA GOSAT instrument provides global XCO2 observations with sensitivity near the surface, which provides an unprecedented opportunity to quantify the global distribution of CO2 fluxes.The newly released ACOS v2.9 observations have corrected the bias in v2.8, and agree with the observations from ground based FTS observations in Total Carbon Column Observing Network (TCCON). **The objective of this study is to quantify surface CO_2 flux from GOSAT v2.9 observations with both OSSE and real observations.**

2. Methods

2.1 GEOS-CHEM adjoint model (Henze et al., 2007)

$$J = \frac{1}{2}[(\mathbf{x}-\mathbf{x}^b)^T\mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}^b)] + \sum_{i=1}^{n}[(\mathbf{y}_i - h(\mathbf{x}))^T\mathbf{R}^{-1}(\mathbf{y}_i - h(\mathbf{x}))]$$

$$\frac{\partial J}{\partial x} = \mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}^b) + \sum_{i=1}^{n}\mathbf{H}^T\mathbf{R}^{-1}[(\mathbf{y}_i - h(\mathbf{x}))], n \text{ is the number of observations.}$$

$\mathbf{H}$ includes the GEOS-chem adjoint model integration.

The optimization iteration process is to find a flux field $\mathbf{x}$ that minimize $\frac{\partial J}{\partial x}$.

We optimize monthly surface CO2 flux. B is the error statistics for $\mathbf{x}$. B is diagonal in this study. $\mathbf{y}_i$ is the ACOS 2.9 observations.

$h(\mathbf{x})$ is the observation operator, which includes the forward integration of GEOS-CHEM.

2.2 The a priori flux inventory

Terrestrial biosphere flux: CASA-GFED3

Biomass burning and biofuel: GFED3

Ocean flux: NASA Ocean Biogeochemical Model (NOBM)

Fossil fuel: CDIAC flux for 2009;

The inventory also includes ship, aviation, chemical production (Nassar et al., 2010)

2.3 OSSE experiments

We optimize the terrestrial biosphere flux only. The observations were based on CASA-GFED3 terrestrial biosphere, while the a priori state was CASA climatology flux (balanced biosphere).

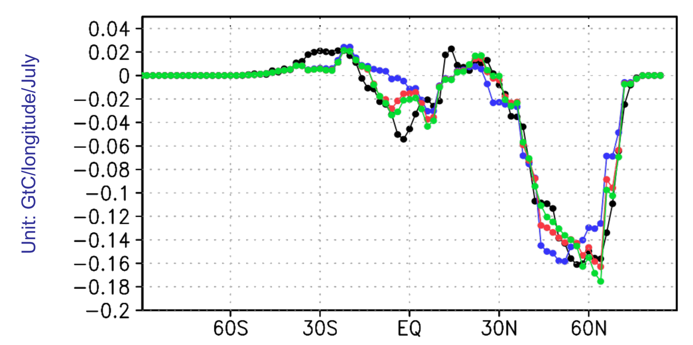
We did two experiments: good-quality ACOS v2.9 observations and all ACOS v2.9 observations. Both data scenarios are cloud free.

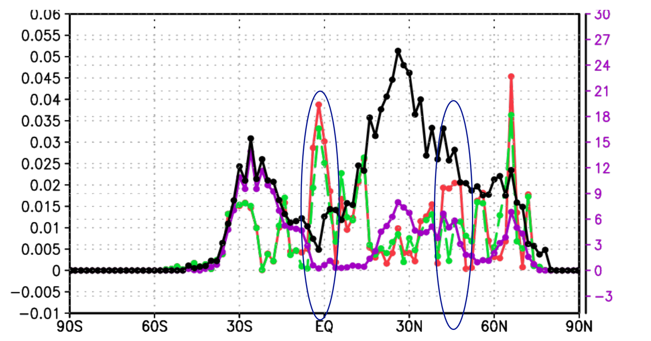
2.4 ACOS v2.9 quality control and bias correction

The quality control is based on the strict quality control recommended by "ACOS Level 2 standard product Data User's Guide v2.9". We further applied the bias correction method documented by Wunch et al. (2011).

3. Results from OSSE for July 2009

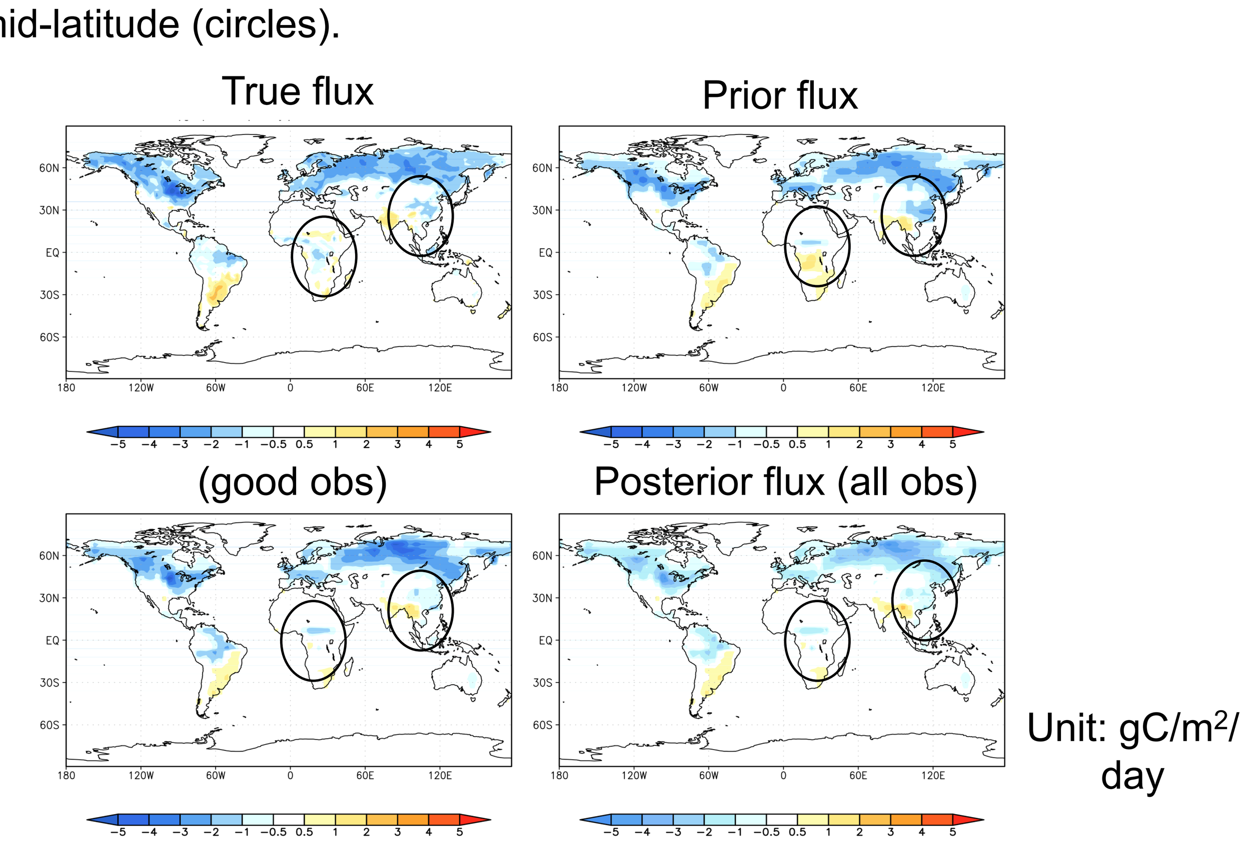
→ ACOS v2.9 recovers most of the "true" flux where the coverage is sufficient; Further improvement on the quality of ACOS v2.9 observations could improve flux estimation in the tropics, and the NH mid-latitude.



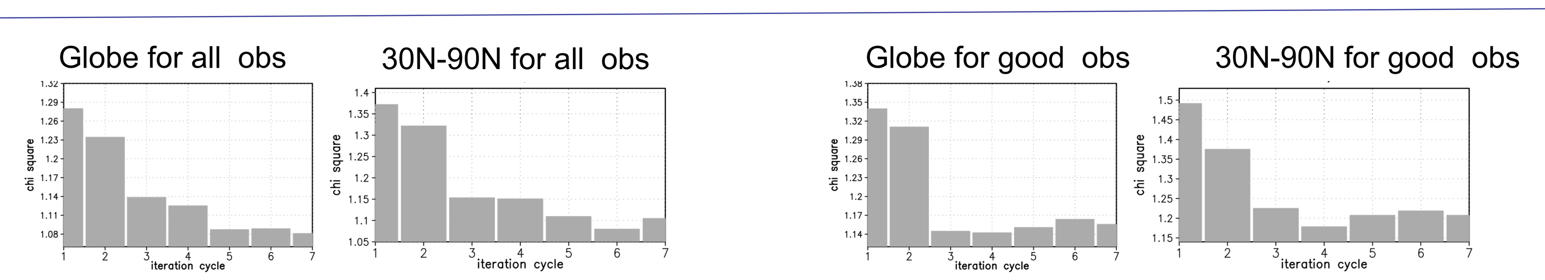


1. Prior error is 9% of the true flux; posterior with good quality observations has 4% error; posterior with all observations has 0.4% error;

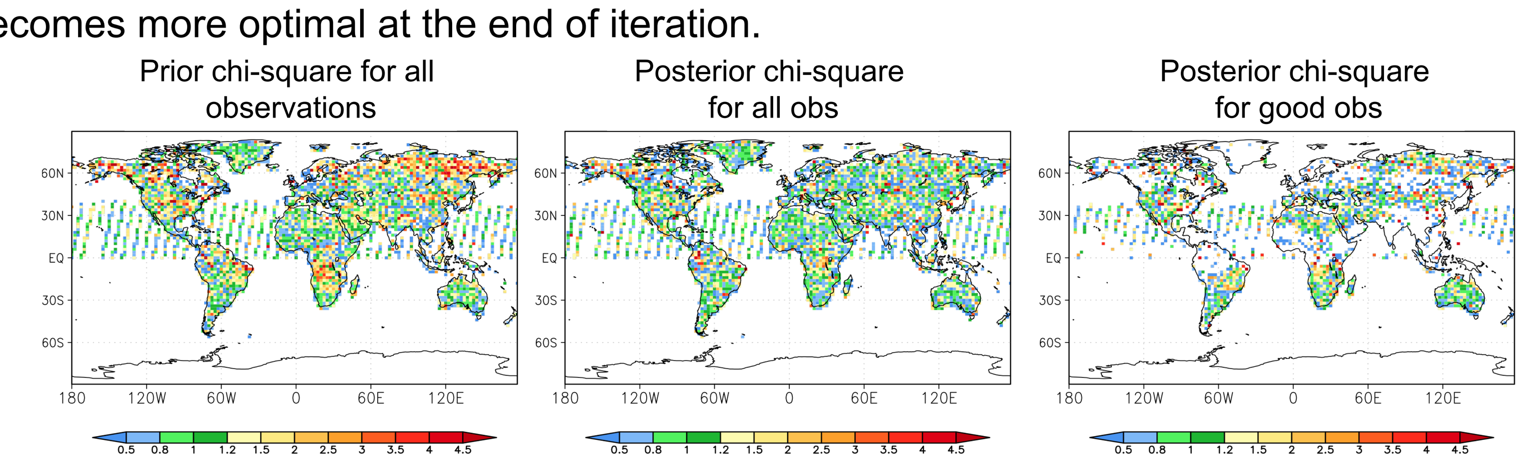
2. Further improvement on ACOS v2.9 could have larger positive impact over the Tropics and the NH mid-latitude (circles).



1. The difference over Eastern Asia (EA), tropical Africa (TA) is larger between the true flux and the prior flux: the prior flux has larger sink over EA, while it is a source over TA.
2. The posterior (bottom two) is much closer to the true flux.



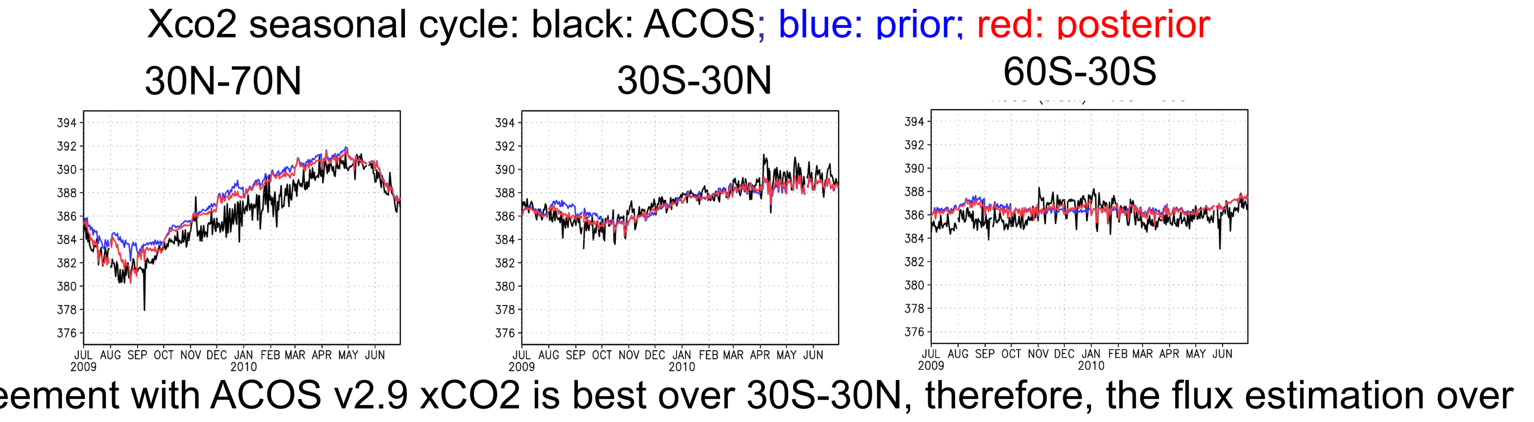
1. Chi-square becomes closer to 1 with iterations; With more observations, chi-square becomes more optimal at the end of iteration.



1. Chi-square (closeness to the observations) has been significantly improved everywhere (mechanically working).

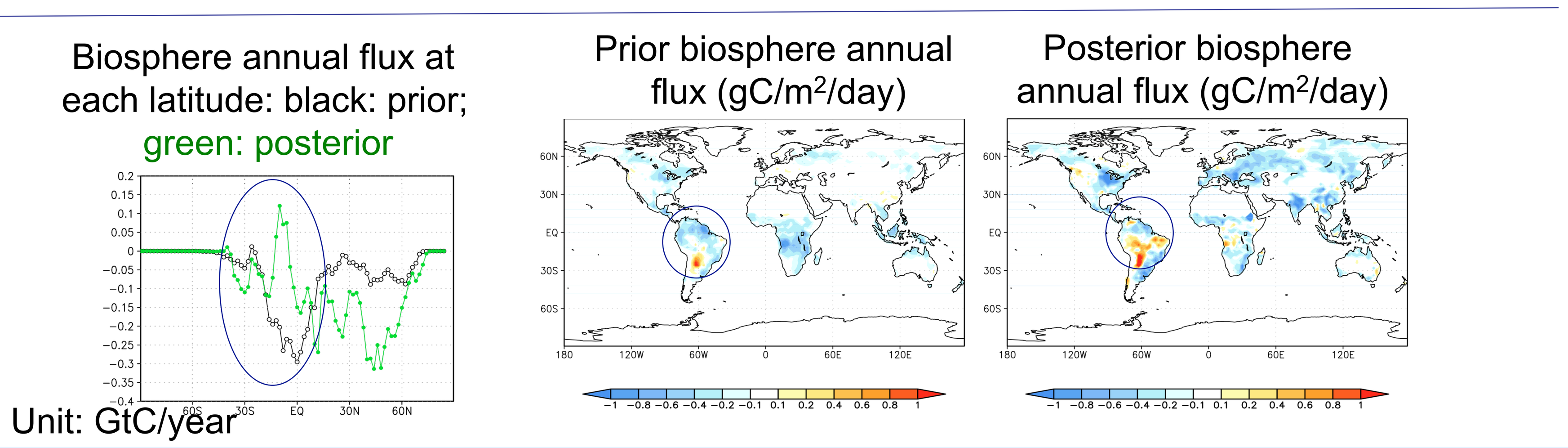
4. Real observation experiments (July 2009-June 2010)

-> Our result indicate South Amazon is a carbon source; the tropical biosphere (30S-30N) has 3.1 GtC/year sink compared to 3.8 GtC/year sink in the prior; tropical biosphere + fire =-1.7GtC/year



1. The agreement with ACOS v2.9 xCO2 is best over 30S-30N, therefore, the flux estimation over 30S-30N is most trustworthy;

2. The big discrepancy between ACOS 2.9 and GEOS-CHEM could from the initial condition, the accumulation effect of ocean or fossil fuel emission.



5. Conclusion and future direction

In this study, we quantified surface CO_2 flux with the newly released ACOS v2.9 observations with both OSSE and real observation experiments. The inversion method is 4D-VAR using geo-chem adjoint model. The results show:

1. Assimilation of ACOSv2.9 observations recovers most of the "true" flux, especially when the simulated observations include both good and bad quality observations; the error is only 0.4% of the true flux.
2. Assimilation of real ACOS v2.9 over July 2009 and June 2010 reveals a total sink of 1.7GtC/year over the tropics (30S-30N) when accounting fire from GFED3; South Amazon region is a source;
3. The NH mid latitude has too much sink, which may come from the influence of ocean (the ocean has weaker sink (0.24GtC/year)) or the error in initial conditions.

In future, we will further optimize the error statics in the 4D-Va: including the spatial correlation in the prior error statistics, and account for transport error. We will quantify ocean flux simultaneously and improve the initial conditions.

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